

GROWTH OF *DIPDOMYS ORDII* (RODENTIA: HETEROMYIDAE)¹

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ABSTRACT.—Growth rates were determined for laboratory-reared *Dipodomys ordii pallidus* Durrant & Setzer. Instantaneous growth rates were used to express increase of body weight, total length, tail length, ear length and hind foot length as rates between times of measurements and the instantaneous percentage of maximum size. Data were analyzed for growth periods of 1–3, 4–15, 16–29 and 30–70 days. All five parameters provided significant correlations of growth with age during all growth periods. Even though all of the growth parameters correlate with age, these parameters cannot be reliably used to predict age.

Dipodomys ordii is one of the most widely distributed small mammal species in North American deserts (Hall and Kelson 1959) and as such occupies a vital position in the bioenergetics of desert ecosystems. Their total role within the ecosystem is not clear, but as primary consumers, they provide an important part of the prey base for higher trophic levels. With increased emphasis being placed on predictive capabilities of productivity within ecosystems, it is desirable to know the potential input of all components. Biomass estimates of rodent populations are often calculated but seldom include estimates for animals below trapable age. *Dipodomys ordii* is no exception. Omission of these types of data is understandable because such data are difficult to obtain, particularly in the field. They are usually provided by laboratory studies, and since *D. ordii* has proven difficult to breed and rear in captivity (Morse et al., in press), no data of consequence have been reported for this species.

Growth rates have been reported for several small mammals (For example, Meyer and Meyer 1944, Pournelle 1952, Chew and Butterworth 1959, Layne 1959, Goertz 1965, Hayden and Gambino 1966, Lackey 1967, Jones 1967, Horner and Taylor 1968, Richins et al. 1974, Lackey 1976, and oth-

ers). These data have aided in understanding productivity, but data on *D. ordii* are unavailable. The objectives of this study were to characterize growth rates of individual *D. ordii* from birth to 70 days of age and to provide a data base for predictive purposes in ecosystem management.

METHODS

The initial specimens of *Dipodomys ordii pallidus* Durrant & Setzer used in this work were live-trapped on the Desert Range Experimental Station, 81 km W of Milford, Millard Co., Utah. Additional animals were obtained from Dugway Proving Grounds, Tooele Co., Utah, and Pahvant Butte, Millard Co., Utah. The laboratory colony was housed at Brigham Young University and maintained at about 85 females and 15–20 males.

Animals were caged individually in glass aquaria or in galvanized metal boxes with sand substrate (about 6.0 cm deep). Nest cans with cotton batting were provided. Water and a food mixture of one part each of sunflower seeds, rolled oats, and pigeon mix were supplied *ad libitum*. Temperature ranged from 20 to 25 C, and the photoperiod was manually graduated to simulate a twilight period.

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Sexes were kept separate except when mating was attempted. Females were checked daily for the external morphologic changes in the vulva that Pfeiffer (1960) described as indicators of estrous. The full flowered vulvar condition was presumed to indicate estrous. At this time a male was introduced into the female's cage. Males were selected for breeding based on the extent of testicular enlargement. Usually, fighting ensued; if the male survived the first few minutes, he was left with the female for 3-4 days. After this period he was returned to a cage with other males. Females were checked for vaginal plugs as an indication of successful coitus.

After litters were born they were not disturbed until the following day, at which time the young were toe clipped and measured. Body weight, total length, tail length, ear length and hind foot length measurements were taken daily from days 1-29 and then weekly through the remainder of 10 weeks. After eyes of the young opened and individuals became more active, they were anesthetized with Penthrane (Abbott Laboratories, North Chicago, Illinois) to facilitate handling and obtaining accurate measurements.

The instantaneous relative growth rate (IGR) described by Brody (1945) and Lackey (1967) was used to express growth as a rate between times of measurements and the instantaneous percentage of maximum size. This rate is expressed as $(dW/dt)/W$, where W is the parameter measured at the instant the rate of change dW/dt is measured. Since it is not entirely possible to develop the "instantaneous" rate of growth, it was necessary to integrate the infinite number of growth rates to derive $W = Ae^{kt}$. This may be conveniently rewritten as—

$$\ln W_{t-1} = \ln A_t + kt$$

where $\ln W$ = natural logarithm of the variable (W), $\ln A$ = natural logarithm of the variable (A) and k represents the instantaneous relative growth rate (when multiplied by 100, k = percentage growth rate). For comparative purposes, the representative IGR (k) is determined with—

$$k_n = \frac{\ln W_n - \ln W_{n-1}}{t_n - t_{n-1}}$$

Thus, k is definitive and can be used to compare differences in rates of growth. Correlation coefficients were calculated between age and growth for the five growth variables studied.

RESULTS

Growth Rates.— Rates of growth along with the instantaneous relative growth rates (k) were determined and are presented for body weight, total length, tail length, ear length and hind foot length (Figs. 1 and 2 and Table 1). When the variables are plotted on a log scale (Figs. 1 and 2), the comparative values of (k) for the growth periods from days 1-70 are illustrated. These results depict growth for animals reared under standardized laboratory conditions and analyzed for time growth periods of 1-3, 4-15, 16-29 and 30-70 days. Other growth periods were graphed and analyzed but these represent the most statistically accurate analyses of *D. ordii* growth.

The R^2 values (Table 1) indicate how much variation is accounted for in the analyses, and when converted to r they can be used to determine statistical significance ($\alpha = 0.05$). A significant r suggests a correlation between the appropriate $\ln W$ (log of the variable) and the age of the growing animals when time is partitioned into growth periods.

All parameters provided significant correlations of growth with age, because r was significant for all growth periods. No individual parameter consistently provided data with the highest significance throughout all growth periods. The significance levels of all parameters are similar for any given growth period; therefore, it is possible to use any of the parameters as an indicator of growth.

Often researchers are more comfortable working with data means (\bar{X}) than with statistics like $\ln W$ and k . Because an understanding of the relationship of $\ln W$ and \bar{X} is important in an interpretation of k , means and standard errors of the growth parame-

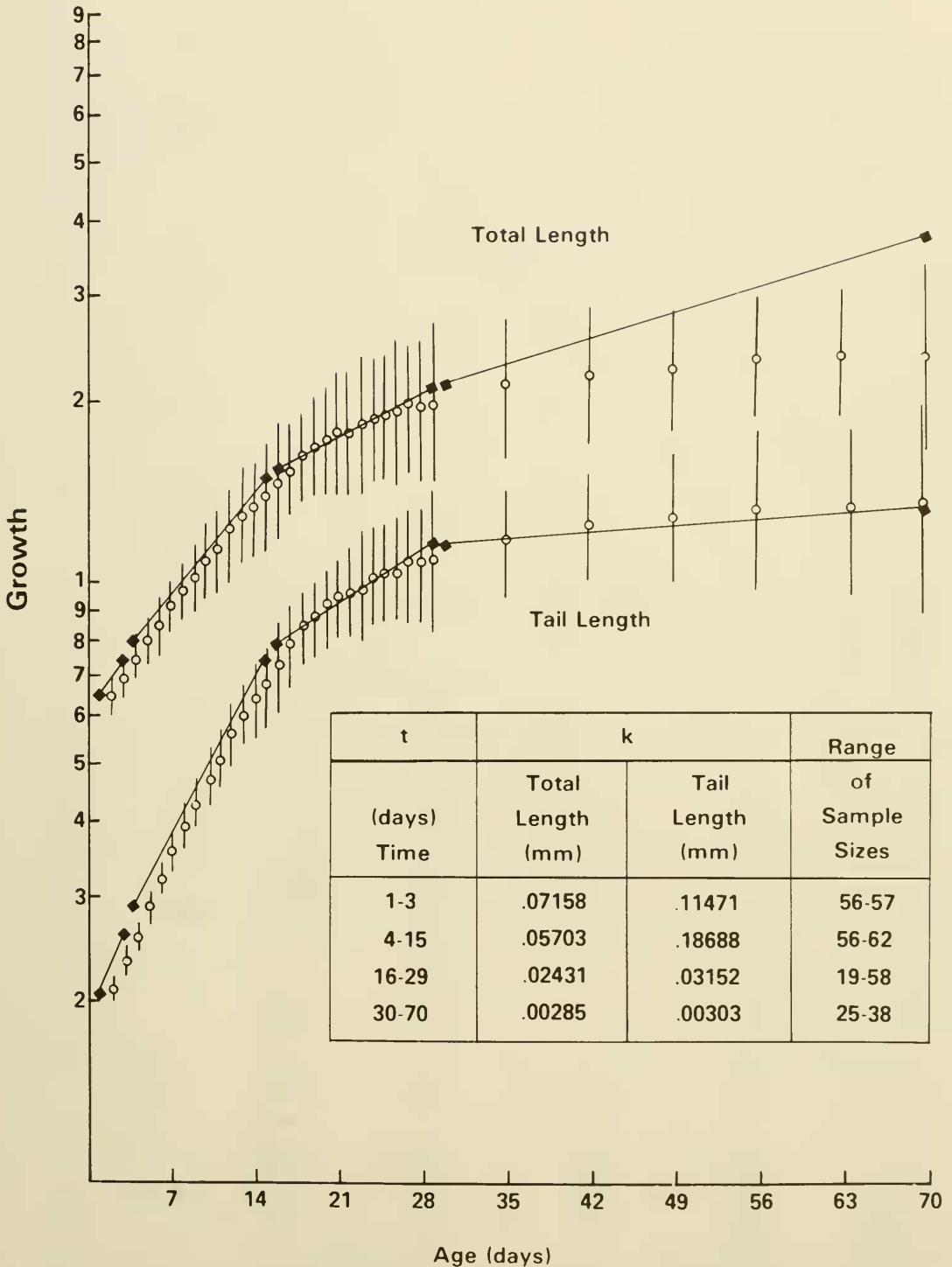


Fig. 1. Means, standard errors ($P=0.95$), and growth rates for total length and tail length of *Dipodomys ordii* reared under standardized laboratory conditions. Growth is expressed in standard measurements described in the text.

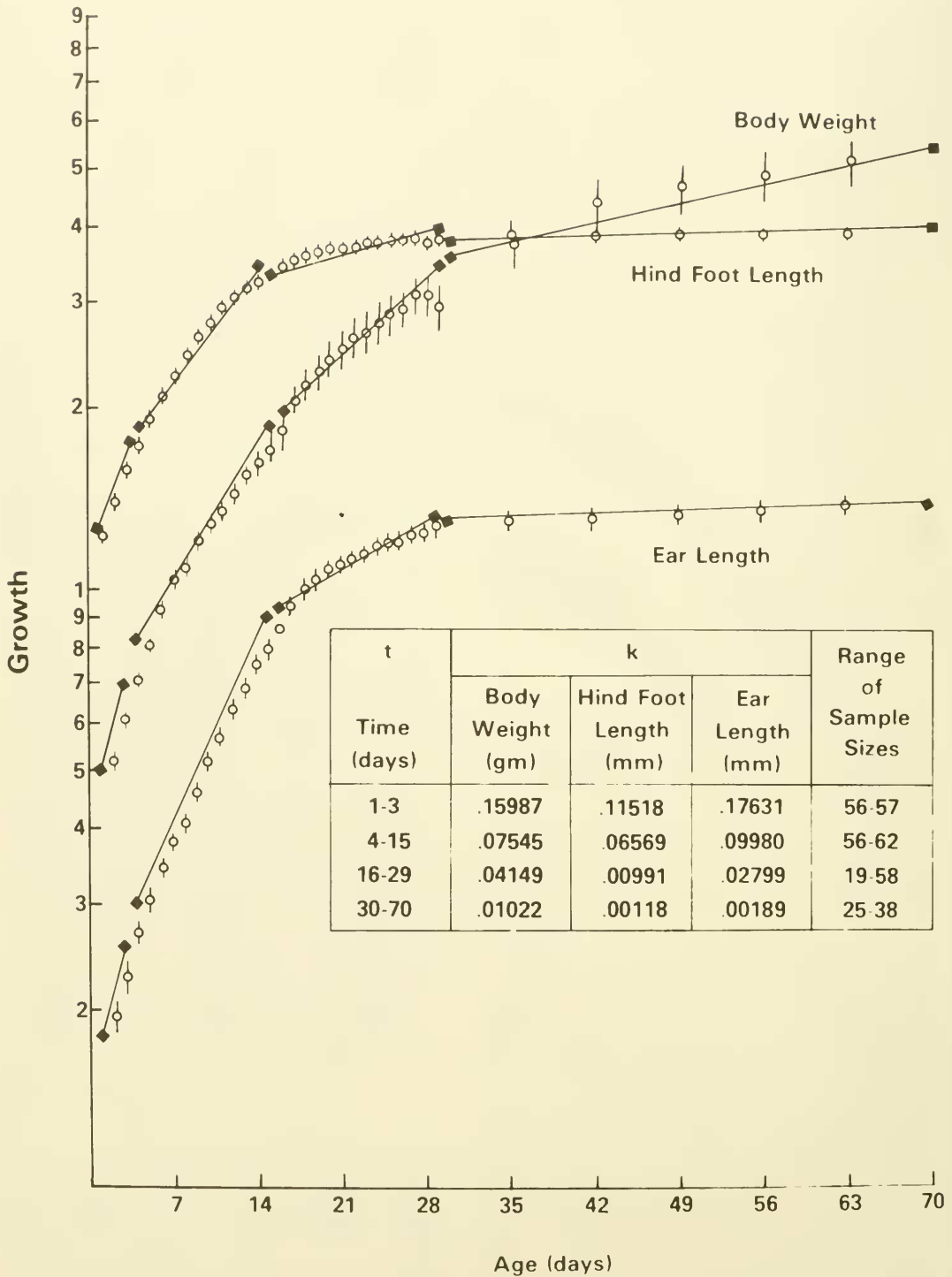


Fig. 2. Means, standard errors ($P=0.95$), and growth rates for body weight, ear length, and hind foot length of *Dipodomys ordii* reared under standardized laboratory conditions. Growth is expressed in standardized measurements described in the text.

ters are compared to the k values for curves (Figs. 1 and 2). Curves for k and \bar{X} are almost identical for all parameters measured, but the confidence intervals of the means for total length and tail length are wider for all growth periods.

Since correlations of growth parameters with age were always significant, one might consider using these parameters to predict age. This procedure is important to an evaluation of the population age structure. Although the process seems evident and convenient, since it would simply involve reading the predicted age from a graph, the results cannot be interpreted with statistical confidence because variation among days is lacking. Calculations of confidence limits about the regression line also present problems; the X axis (age) is a nonrandom variable selected by the investigator. Thus, only the regression of Y on X can be estimated with confidence. It is possible that non-parametric procedures could be utilized to provide predictive capabilities (Dapson and Irland 1972).

DISCUSSION

Ideally, growth data should be collected under field conditions, but the difficulty of such collection for animals below trappable age causes biologists to revert to the laboratory where organisms can be confined and environmental influences controlled. The growth data analyzed for *D. ordii* are for animals grown under standardized laboratory conditions simulating mean temperatures and photoperiods encountered by animals during active periods of growth in western deserts. Although all R^2 values were significant (when converted to r) at the $P = 0.95$ level, one must consider two constraints in their interpretations: (1) the size of n , which when too large reduces the usefulness of r , and (2) the percentage of the variation that must be accounted for before significant correlations are considered biologically acceptable and k is accepted as a reliable estimate of the instantaneous relative growth rate. When the growth curves (Figs. 1 and 2) are examined, the correla-

TABLE 1. Summary of analyses for growth of *Dipodomys ordii pallidus* reared under standardized laboratory conditions.

Parameter	lnA	Antilog of lnW	Age in Days ($t = t-1$)	R^2	Correlation Coefficient (r) ^a
Total length	4.09464	74.44	1-3	0.29843	0.54628°
	4.15655	149.90	4-15	0.79170	0.88977°
	4.65890	210.61	16-29	0.49748	0.70532°
	5.27545	237.46	30-70	0.28872	0.53732°
Tail length	2.92560	23.31	1-3	0.21841	0.46734°
	3.02929	75.18	4-15	0.76737	0.87597°
	3.87084	117.92	16-29	0.40309	0.63489°
	4.68195	132.95	30-70	0.12449	0.35283°
Body weight	1.47177	7.03	1-3	0.25465	0.50462°
	1.80782	18.73	4-15	0.64611	0.80380°
	2.33647	34.12	16-29	0.44996	0.67079°
	3.29270	55.15	30-70	0.60571	0.77827°
Ear length	0.45680	2.66	1-3	0.23211	0.48177°
	0.71373	9.03	4-15	0.82902	0.91050°
	1.79442	13.20	16-29	0.58465	0.76461°
	2.48377	13.73	30-70	0.20396	0.45161°
Hind foot length	2.40433	16.64	1-3	0.33954	0.58270°
	2.61515	36.23	4-15	0.81333	0.90184°
	3.37601	38.86	16-29	0.39367	0.62743°
	3.59137	39.24	30-70	0.16730	0.40902°

^aSignificant at $\alpha = .05$

tions (r) and comparisons of k with the data means and standard errors seem precise within the prescribed growth periods. One is thus inclined to be rather liberal in setting lower limits on R^2 and accepting the curves as representing the actual growth of *D. ordii* for the time intervals under the controlled conditions. It was determined that $R^2 \geq 0.25$ should provide enough accountability to accept significant correlations and to realistically represent the growth rates. This does not mean that the k values for those analyses with $R^2 < 0.25$ are in error; it means the confidence is not as strong, and caution should be exercised in using these data for actual growth in modeling and predictive situations.

Total body weight is perhaps the most interesting of all parameters measured. It determines biomass and relates to secondary production. Because there are such close relationships between the antilogs of $\ln W$ and means, and because there are such narrow confidence limits about the means, antilogs of $\ln W$, means, and k values for body weight should accurately represent the instantaneous relative growth rates for periods up to 70 days of age. Therefore, body weight can be used to predict biomass of animals prior to trappable age. Beyond 70 days the correlations of body weight with age become less reliable, but, because the animals are now trappable and have reached adult size, their productivity can be measured in the field. After 70 days, a close correlation is not necessary because k shows very little increase as evidenced by the body weight curves (Fig. 2). Although the growth rates were obtained under standardized laboratory conditions, they can be considered generally representative for the growth periods prescribed. These growth periods include times when the animals are undergoing normal active growth. Following this time period, weight varies in response to environmental stresses and changes rather than actual growth phenomena.

One possible weakness of these analyses is an inability to assess k under field conditions. Originally, it was assumed that shifts in k under field conditions would not differ

significantly from those established in the laboratory, but analyses of data obtained while experimenting with independent variables (photoperiod, temperature and food) for *Peromyscus maniculatus* suggest that this assumption may not be valid. Manipulation of photoperiod, temperature, and food caused k to vary for growth of *P. maniculatus*, but the k values only varied early in the growth period. By the time the animals reached trappable age k values for body weight, regardless of the independent variable changes, were similar. It is possible that interactions of the variables might compensate for one another and reflect no change in k . If so, estimates of biomass could still be made by correlating body weight with age.

There have been several attempts to correlate weight with age and other parameters (Brody 1945, Dapson and Irland 1972 and others) but, because many of them attempted to predict age, the results were not particularly satisfying. Calculation of confidence limits about the regression line is not possible because the X axis (age) is a nonrandom variable, selected by the investigator. This study was concerned more with the characterization of growth as far as weight was concerned. Attempts to age organisms should be done with parameters other than body weight, such as dried eye lens weight or perhaps with tyrosine content of lenses (Dapson and Irland 1972).

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